Convertible Bond Arbitrage*

1. Introduction

In its most basic form, convertible bond arbitrage involves purchasing a convertible bond (often referred to interchangeably as "convertible debt" or "convertible debenture") and taking a short position in the stock of the issuing company. Arbitrage opportunities arise when the convertible bond's market price differs from its fundamental or theoretical value. For most of these mispricings, convertible bonds trade "cheap" relative to their theoretical values. However, there are occasions when the convertible bond trades "rich" relative to the underlying stock. In these situations, an arbitrageur may short-sell the convertible bond and offset this position by taking a long position in the underlying stock.

Convertible bonds have historically been an essential source of financing for firms with negative or volatile cash flows, particularly those that face challenges accessing traditional debt markets. Conceptually, a convertible bond is essentially straight debt plus a call option on the issuer's equity, packaged into a single security. This hybrid nature appeals to issuers, as it offers a lower coupon rate than traditional debt while granting bondholders the upside potential of equity conversion.

Although convertible securities represent a relatively small fraction of the aggregate balance sheets of publicly traded corporations, issuers tend to find convertible bonds attractive as a last-resort financing tool. Firms that issue convertible bonds typically do so when access to traditional debt or

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equity markets is constrained. Arbitrageurs and hedge funds have historically played an essential role in the convertible bond market, primarily by providing issuers with immediate liquidity. Arbitrageurs frequently account for more than half of the aggregate ownership of convertible bonds, reflecting their importance to the market.

Convertible bonds share many characteristics with traditional corporate bonds. They typically pay a fixed interest rate, have a stated maturity date, and pay interest semi-annually. Importantly, like traditional corporate debt, a convertible bond has an indenture that details the specific terms of the bond, such as the coupon rate and conversion rate, and notably establishes the rights and priorities for the convertible bond holder in the event of a default by the issuer or other breach that would negatively impact the convertible bond. The conversion feature distinguishes convertible bonds from traditional corporate debt, allowing the holder to convert the bond into the issuer's stock. This optionality is the linchpin of convertible bond arbitrage.

Figure 1 illustrates the key features of a hypothetical convertible bond. The solid blue line depicts the convertible bond's face value at maturity, with the issuer’s stock price on the horizontal axis. Like most corporate bonds, the typical convertible bond has a par value of $1,000. The conversion feature of a convertible bond allows the owner to exchange the bond for a predetermined number of shares of the issuer's stock:

$$\text{Conversion Ratio} = \frac{\text{Par Value}}{\text{Conversion Price}}$$

For example, if the issuer sets the conversion price at $25.00 at the time of issuance, the owner of the convertible bond has the option to convert the bond into 40 shares of the underlying stock. At maturity, the bondholder will redeem the bond for $1,000 if the stock price is below $25.00, as converting the bond to stock will yield less value. Conversely, if the stock price exceeds $25.00, the bondholder will convert the bond into shares, realizing a higher value than if redeemed for cash. All other factors being equal, the holder is indifferent between redeeming the bond for cash or converting it to shares when the stock price equals the conversion price of $25.00.[1]

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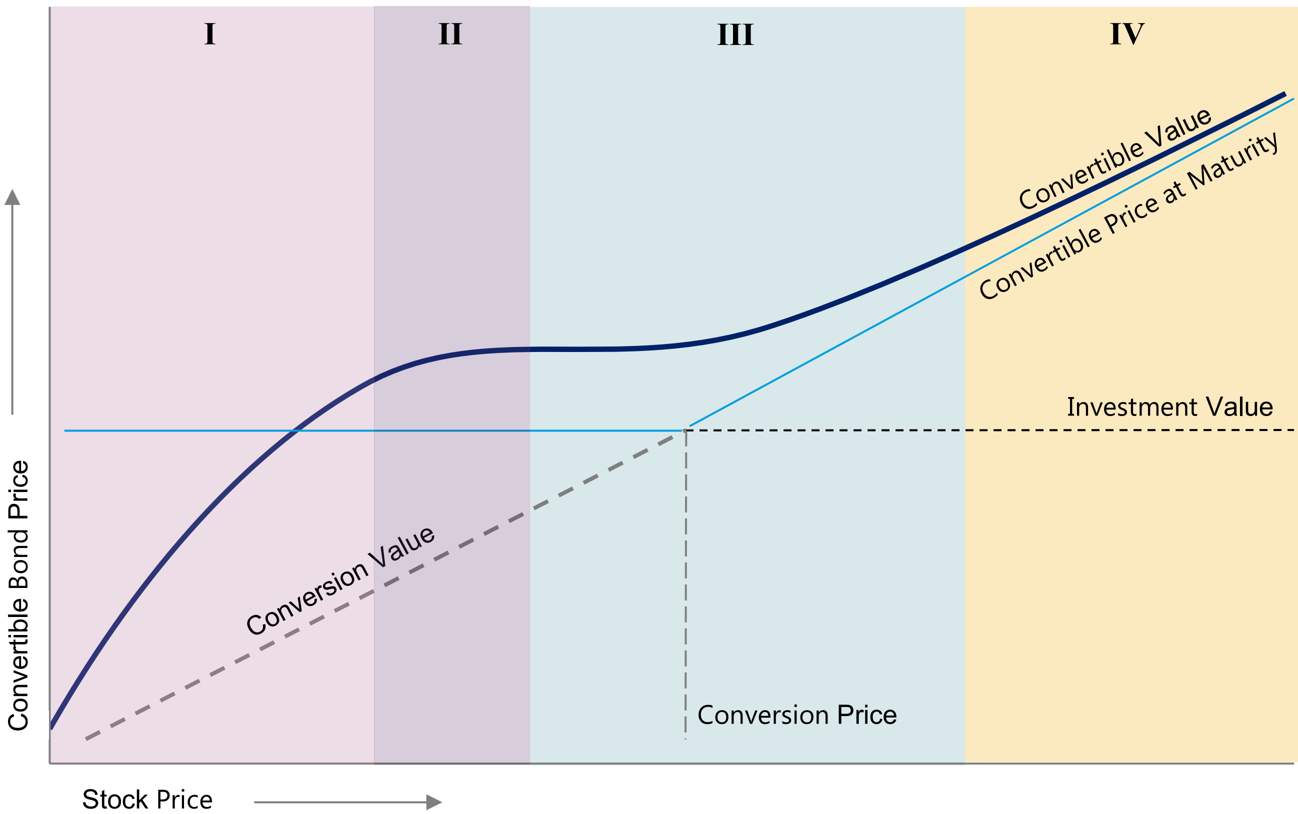
[1] The dashed lines reflect the suboptimal investment and conversion values at maturity. For example, the bond value is less than the conversion value at maturity when the stock price exceeds $25.00. Similarly, the conversion

Figure 1: Key Features of a Hypothetical Convertible Bond



The blue curved line in Figure 1 illustrates the convertible bond's fundamental value well before maturity, such as at issuance, as a function of the underlying stock price.[2] In the first region (I), the bond's value drops below its par value for extremely low stock prices because it is not risk-free. Thus, the holders will not likely receive par value in bankruptcy. The hypothetical convertible bond in Figure 1 retains some positive value based on an assumed recovery amount in the event of default, reflecting the seniority of bondholders over stockholders. The recovery value could be higher or lower than the estimate provided in Figure 1 or even zero.[3]

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value is less than the bond value for stock prices less than $25.00.

[2] The blue curved line is strictly for a hypothetical convertible bond. It will vary considerably across different convertible bonds with the same expected time to maturity and for the same convertible bond with varying times to maturity.

[3] Consider, for example, a firm with secured or senior debt higher in priority than the convertible debt. If the assets cannot cover their claims fully, the convertible debt holders will not share in the recovery value.

The second region (II) contains "busted" convertibles, bonds well out of the money but not necessarily distressed. These bonds trade more like straight debt instruments than equities. In this region, the slope of the blue curved line is relatively flat, reflecting minimal sensitivity to changes in the underlying stock price. These convertibles are even less sensitive to stock price movements than those in the distressed quadrant, but are highly sensitive to credit and interest-rate risk. At maturity, holders of busted convertibles will redeem the bonds, expecting a full recovery of the par value.

Region III includes the most sought-after group of convertibles, often labeled as "hybrid" or "total return" convertible bonds. These convertible bonds exhibit significant sensitivity to credit, equity, and interest-rate factors instead of being predominantly credit and interest-rate-sensitive or equity-sensitive. Holders of these bonds often view them as offering the potential for substantial upside due to their equity-like features while also providing regular coupon payments and seniority over equity holders in the event of financial distress. In addition, this range includes convertibles where the issuer's stock price exceeds the conversion price but not by a significant amount, meaning the bonds are in the money but still have considerable credit and interest-rate risk.

Region IV contains predominantly equity-like convertibles, exhibiting minimal sensitivity to credit and interest rate fluctuations. These bonds are typically deep in the money, with a high likelihood of conversion into equity at maturity. As the moneyness (stock price divided by conversion price) of these convertibles increases, their fundamental value approaches the conversion value of the underlying stock. Consequently, their price movements are closely correlated with the stock price, reflecting their equity-like nature.

Figure 1 shows how the convertible bond's sensitivity (the "delta" as discussed in later sections) evolves across the issuer's stock price range. This sensitivity significantly impacts how the convertible arbitrageur will hedge a convertible bond. The most straightforward situation involves a convertible bond that is in Region IV and well in the money. In these cases, the hedge is straightforward and primarily includes the underlying stock as the hedge. However, an arbitrageur will also account for interest rate and credit risks associated with convertible bond types in the first three regions, supplementing the stock hedges with additional hedging instruments. As we shall explore in detail, these considerations are central to understanding and managing a convertible bond arbitrage strategy.

This lecture note aims to describe several of the processes involved with convertible bond arbitrage, focusing on practical, real-world examples rather than abstract theoretical concepts. Section 2 thoroughly analyzes a new convertible bond issue by Kosmos Energy in 2024. It describes a valuation analysis for the Kosmos Energy convertible bond and its associated hedges that an arbitrageur might employ. Section 3 discusses convertible bond trading and hedging in the secondary market, distinguishing between direct and indirect hedges. Section 4 describes differences in hedging strategies for two convertible bonds: one issued by Snap, Inc., characterized by low moneyness, and another by MakeMyTrip, Ltd, featuring high moneyness. Section 5 examines the financing structure of a convertible arbitrage portfolio, emphasizing the leverage and capital considerations required for effective portfolio management. Section 6 concludes the lecture note.

2. New Convertible Bond Issue (Kosmos Energy)

The Issuance Process

This section details the valuation of a convertible bond using the example of Kosmos Energy (NYSE: KOS), an oil and gas exploration company. After the market closed on March 4, 2024, Kosmos issued a press release announcing a $300M offering of convertible bonds, or up to $345M if the underwriter exercised their standard 15% overallotment. The press release indicated that the convertible bonds would be senior, unsecured obligations and rank equally with the existing senior debt. Kosmos planned to use most of the funds to repay some of its outstanding debt.

Soon after Kosmos Energy issued the press release announcing the new convertible offering, its investment bankers circulated a term sheet to large prospective institutional investors, including convertible arbitrageurs and hedge funds, outlining the marketed terms. These terms included:

(a) interest rate between 2.75% and 3.25%, paid semi-annually,
(b) conversion premium range of 27.5% to 32.5%,
(c) March 2030 maturity.

In addition, Kosmos' investment bankers provided suggested inputs for investors to consider when analyzing the new convertible. These inputs included an annual stock return volatility of 40% for Kosmos and a credit spread of 600 basis points (6.0%), roughly corresponding to a Moody's B3 credit rating. The investment bank derived these inputs through discussions with company management and buy-side participants, observations of market conditions, and its business judgment. While investors, such as arbitrageurs, will use the investment bank's suggested inputs as a baseline, they typically perform their own analyses to develop estimates for volatility and credit spreads.

Kosmos Energy's first venture into the convertible bond market generated a sharp adverse reaction from the stock market. On March 5, 2024, when investors could first trade on the new issue announcement, Kosmos’ stock price dropped by 10.2%, from $6.01 to $5.40. This decline marked Kosmos's most significant single-day price decline since November 2022. Additionally, trading volume surged to 34.4 million shares, the highest daily trading volume since October 2021 and over eight times the average daily trading volume since Kosmos stock began trading in 2011.

Two factors contributed to the steep decline in Kosmos’s stock price on March 5, 2024: information asymmetry and short selling by arbitrageurs. First, Kosmos’s decision to issue a convertible bond, an equity-linked security, rather than traditional debt, may have signaled to investors that the company’s management believed the stock market was overvaluing the stock price of Kosmos. Second, short selling by arbitrageurs often occurs after the announcement of the convertible issue and before the arbitrageurs receive their allocation. Frequently, arbitrageurs will short Kosmos stock based on their expected allocation of the new convertible bonds, aiming to have their positions at least partially hedged once they receive their allocations. This short selling by arbitrageurs typically causes a modest decline in the stock price. However, in Kosmos’ case, the 10.2% decline was far more significant than the usual 2-3% decline observed around new convertible bond issues.

Valuing the New Convertible Bond

Investors can value the Kosmos convertible bond based on the suggested range of terms and structural features such as call and put dates, make-whole tables for dividends and takeovers, and other specific terms. Below, we begin by valuing the convertible bond using the underwriter's volatility and credit spread recommendations of 40% and six hundred basis points, respectively. We also use the “settled” March 5, 2024, stock price of $5.40, incorporating new information from the convertible issue announcement. Later, we provide valuation estimates using volatility and credit spread inputs from a hypothetical arbitrageur.

While many investors use proprietary convertible pricing models, vendors such as Bloomberg, Kynex, and Monis provide convertible pricing models for market participants. Investors often employ internal and external models to ensure consistent valuation estimates across different methodologies. In our example below, we use the Bloomberg pricing model to value the Kosmos convertible bonds so readers of this article, without access to proprietary pricing models or subscriptions to specific convertible valuation models like Kynex and Monis, can verify our results.

Table 1: Kosmos Energy Convertible Bond Valuation Estimates (Underwriter Inputs)

Coupon vs Conversion Premium	27.5	30.0	32.5
2.75	102.12	100.97	99.87
3.00	102.39	101.90	100.80
3.25	103.98	102.83	101.74

Source: Bloomberg Convertible Bond Pricing Model. Table 1 displays valuation estimates for the Kosmos Energy convertible bonds using the stipulated inputs across the specified coupon rate and conversion premium ranges, including the midpoints. The highest coupon rate and lowest conversion premium combination generates the highest valuation estimate, while the lowest valuation results from the lowest interest rate and the highest conversion premium.

At the midpoints—a coupon rate of 3.00% and a conversion premium of 30%—the convertible bond's model value is 101.90, indicating the convertible is 1.90% "cheap" relative to par value. At the highest interest rate of 3.25% and the lowest conversion premium of 27.5%, the convertible bond's model value rises to 103.98. This scenario represents the most attractive pricing given the inputs. At the opposite end of the spectrum, with an interest rate of 2.75% and a conversion premium of 32.5%, the convertible bond's value drops to 99.87, making the bond 0.13% overvalued (rich) if priced at par. Aside from this scenario with the least favorable terms, the Kosmos Energy convertible bond is attractively priced based on the investment bank's provided inputs and the underlying stock price of $5.40.

When evaluating new convertible bonds, investors consider the underwriter's suggested inputs, such as volatility and credit spreads, alongside their proprietary estimates of these inputs. Below, we outline a hypothetical arbitrageur's selection of input estimates and then recompute the value of Kosmos's convertible bond. For volatility, the goal of the hypothetical arbitrageur is to derive an unbiased estimate of volatility for the stock price of Kosmos over the expected life of the convertible bond.[4] Although the Kosmos convertible bond has a stated life of six years, factors such as bankruptcy, merger, or refinancing can shorten this period, resulting in an expected life of less than six years.

[4] We are not suggesting that all convertible arbitrageurs derive unbiased estimates of inputs to value convertible bonds; instead, we are doing so simply in the context of our hypothetical arbitrageur to convey the cheapness or richness of the convertible bond relative to unbiased market inputs.

For Kosmos, long-dated stock options would ideally exist, allowing the hypothetical arbitrageur to match the option's maturity date to the convertible's expected life and align the strike price with the conversion price. However, long-dated stock options are typically only available for large corporations. Consequently, arbitrageurs rely on implied volatility from shorter-dated stock options. Often, even shorter-dated options are unavailable, especially for smaller corporations, and the arbitrageur will use historical volatility estimates to establish their forecast of future volatility.

Table 2 displays stock options data from Bloomberg for Kosmos Energy as of March 5, 2024, coinciding with its new convertible bond issuance. The longest-dated stock option for Kosmos expires in January 2025, less than a year from the new convertible pricing date. Due to Kosmos's small market capitalization, its options trade infrequently. The highest open interest is in the call options with a $7.50 strike price, which is closest to the new convertible's conversion price of $7.02 (given a 30% conversion premium). The average implied volatility of the bid-ask spread for the $7.50 strike price is 44.7%, and the implied volatility of the last traded contract is 44.5%, higher than the underwriter's recommendation of 40%.

Table 2: Stock Option Prices and Implied Volatilities for Kosmos Energy

Ticker	Strike	sDM	Bid	Ask	Last	IVM	Volm	IVB	IVA	OInt
15-Mar-24 (10d); CSize 100										
KOS 3/15/24 C3	3.00	1.000	2.25	2.55					300.44	
KOS 3/15/24 C4	4.00	1.000	1.20	1.55					182.25	7
KOS 3/15/24 C5	5.00	.797	.40	.55	.49	56.86	4		81.95	535
KOS 3/15/24 C6	6.00	.245		.10	.04	76.54	69		76.54	540
KOS 3/15/24 C7	7.00	.108		.05	.05	108.36	4		108.36	157
19-Apr-24 (45d); CSize 100										
KOS 4/19/24 C3	3.00	1.000	2.25	2.60					158.83	
KOS 4/19/24 C4	4.00	.871	.80	2.35	1.75	90.66	10		236.83	18
KOS 4/19/24 C5	5.00	.705	.55	.80	.65	56.11	32	36.47	74.43	109
KOS 4/19/24 C6	6.00	.300	.10	.20	.20	44.44	294	36.69	51.72	463
KOS 4/19/24 C7	7.00	.167		.10	.05	64.79	9		64.79	778
21-Jun-24 (108d); CSize 100										
KOS 6/21/24 C3	3.00	.875	2.25	3.50		151.20			249.78	
KOS 6/21/24 C4	4.00	.918	1.45	1.60	1.60	46.13	51		59.98	51
KOS 6/21/24 C5	5.00	.691	.75	.85		46.69		41.85	51.48	425
KOS 6/21/24 C6	6.00	.411	.30	.40	.40	46.08	1	41.69	50.42	148
KOS 6/21/24 C7	7.00	.212	.10	.20	.20	47.77	15	41.52	53.37	695
19-Jul-24 (136d); CSize 100										
KOS 7/19/24 C3	3.00	.945	2.30	2.80	2.85	74.62	1		121.01	2
KOS 7/19/24 C4	4.00	.811	1.15	2.65		87.52			167.03	611
KOS 7/19/24 C5	5.00	.692	.80	.95		46.41		39.92	52.80	2
KOS 7/19/24 C6	6.00	.434	.35	.45	.45	44.03	16	40.17	47.86	423
KOS 7/19/24 C7	7.00	.233	.15	.20		44.50		41.97	46.94	171
18-Oct-24 (227d); CSize 100										
KOS 10/18/24 C3	3.00	.948	2.40	2.75		56.21			83.31	
KOS 10/18/24 C4	4.00	.867	1.50	1.90		45.35			64.22	
KOS 10/18/24 C5	5.00	.688	1.05	1.15		47.90		44.64	51.14	100
KOS 10/18/24 C6	6.00	.492	.50	.70	.69	43.76	21	37.98	49.54	31
KOS 10/18/24 C7	7.00	.319	.25	.40		43.22		38.25	47.98	15
17-Jan-25 (318d); CSize 100										
KOS 1/17/25 C2.5	2.50	.959	2.80	3.40		61.13			103.50	29
KOS 1/17/25 C5	5.00	.695	1.25	1.40	1.35	50.90	46	46.75	55.05	1651
KOS 1/17/25 C7.5	7.50	.329	.35	.45	.40	44.72	67	42.00	47.39	4093
KOS 1/17/25 C10	10.00	.130	.10	.15	.15	44.57	2	42.15	46.78	906
KOS 1/17/25 C12.5	12.50	.095	.05	.15		53.19		46.34	58.37	44

Source: Bloomberg

Even when stock options data is available, thereby providing estimates of future volatility, arbitrageurs may also consider the underlying stock's historical volatility. Kosmos's annualized volatility, based on daily returns over the past year is 44.9%, and 66.1% over the past three years. In some cases, arbitrageurs will use a weighted average of historical and implied volatility to determine the best estimate for volatility in convertible security pricing. Examining the term structure of various index options, such as the S&P 500, can be insightful. Suppose S&P 500 options indicate a meaningful decline in implied volatility beyond January 2025. In that case, longer-dated options for Kosmos would likely show a similar decrease in implied volatility past January 2025.

When assessing credit risk, the primary goal is to determine the credit spread, which is the difference between the yield of comparable straight debt and a similar-duration U.S. Treasury bond. An effective instrument for calculating a company's credit spread is a credit default swap (CDS) contract that matches the maturity and priority of the convertible bond. Because a CDS references only credit events, it isolates default risk and excludes interest-rate risk: The CDS spread compensates for expected default losses and recovery, not for movements in Treasury yields. Accordingly, when available, the CDS spread is often the cleanest observable proxy for an issuer's credit spread. However, like long-dated options, CDS contracts are mainly available for large corporations and do not exist for Kosmos.

Kosmos has other outstanding debt that can serve as a valuable reference for estimating the credit spread of the new convertible bond. The company has three senior unsecured bonds with a total face value of approximately $2.1 billion. To use one as a proxy, the arbitrageur will first strip out the interest-rate component by measuring its yield relative to a matched-duration U.S. Treasury, leaving a residual spread that primarily reflects credit risk.[5] When relying on this proxy for the convertible's credit spread, it is essential to consider the reference bond's liquidity as illiquid bonds can exhibit an inflated spread due to a liquidity premium and to adjust for maturity differences by mapping the spread to the convertible's expected life along the issuer's credit curve.

The most comparable bond in Kosmos' capital structure at issuance was a $600 million debenture due on March 1, 2028, which has a credit spread of 530 basis points. This credit spread aligns with four-year bonds of firms rated B2, the middle bucket of high-yield debt rated by Moody's. Note that the credit spread for six-year bonds rated B2 was roughly 100 basis points higher than for four-

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[5] Practitioners often formalize "spread to Treasuries" with a z-spread, the constant spread added to every point on the Treasury zero-coupon curve that equates discounted cash flows to price. If the straight bond has embedded options, they use an option-adjusted spread (OAS), which nets out the option's model value. Both measures are intended to isolate credit after removing the risk-free term structure (interest-rate/time-value) component.

year bonds with the same rating. Thus, our hypothetical arbitrageur takes the credit spread of 530 basis points from Kosmos' straight bonds, which mature in four years, adds the additional credit spread of 100 basis points, and arrives at an estimated credit spread of 630 basis points for a six-year debt issue for Kosmos, close to the underwriter's suggested credit spread of 600 basis points.

Arbitrageurs also conduct fundamental financial analyses to assess the credit quality of the underlying issuer. This analysis involves reviewing the company's financial statements, reading financial analyst reports about the company, and analyzing current market conditions that could influence credit spreads. While arbitrageurs broadly hedge out credit exposure, it is difficult to fully hedge significant credit moves due to jumps to default and other major adverse idiosyncratic events without materially eroding returns to the upside. Therefore, as a final check, the arbitrageur will usually confirm that their convertible arbitrage portfolio can handle its exposure to the bond's credit, irrespective of the stock hedge, which we will discuss subsequently, as the stock hedge will incorporate the company's credit risk for small changes in firm values but not for dramatic downside moves.

Assume our hypothetical arbitrageur uses the last traded implied volatility of 44.5 percent as the volatility input and the duration-adjusted credit spread of 630 basis points as the credit input. Table 3 compares the bond valuations using the arbitrageur's inputs versus the underwriter's inputs (shown in parentheses). The net effect of a higher volatility input (44.5 percent versus 40.0 percent) and a higher credit spread (630 basis points versus 600 basis points) from the arbitrageur's inputs results in an overall higher valuation across the matrix of terms compared to those using the underwriter's inputs. The higher convertible bond valuation stems from the fact that the increase in volatility more than offsets the increase in the credit spread.

Table 3: Kosmos Convertible Bond Valuation Estimates (Proprietary vs. Underwriter Inputs)

Bond Fair Values (Coupon vs Conversion Premium)	**27.5**	**30.0**	**32.5**
2.75	103.61 (102.12)	102.44 (100.97)	101.32 (99.87)
3.00	104.54 (102.39)	103.37 (101.90)	102.25 (100.80)
3.25	105.46 (103.98)	104.30 (102.83)	103.18 (101.74)

Source: Bloomberg Convertible Pricing Model. Valuation estimates based on underwriter inputs are in parentheses and are identical to the estimates in Table 1.

The other inputs the hypothetical arbitrageur uses to value Kosmos' convertible issue are the same as those used to generate the valuation with the investment bank's inputs. Both analyses use the same traded stock price of $5.40 rather than a fundamental stock price estimate. They also both employ the actual U.S. Treasury term structure instead of a subjective assessment of the rate structure. It is important to note that the Kosmos convertible bond does not price cheap (relative to par) due to subjective estimates of various inputs.[6] This cheapness is typical as corporations usually issue convertible bonds at prices lower than their fundamental or theoretical values to encourage investors to participate in their new issues. We will also later note that convertible bonds generally trade cheaply in the secondary market, which we attribute to a liquidity premium, given that convertible bonds are usually less liquid than the underlying stocks.

It is not unusual that the valuation of the Kosmos convertible bond was slightly higher with the inputs from the hypothetical arbitrageur than when using the suggested inputs by the investment bank managing the offering for Kosmos. From our experience, the input estimates from issuers' investment banks are typically more conservative, resulting in lower valuations than those derived from unbiased market estimates of volatility and credit spreads.

Establishing the Purchase (and the Hedge)

Once the arbitrageur has completed the valuation of Kosmos's convertible bond, they will indicate demand for the new issue based on a matrix of the suggested coupon rates and conversion premiums, as shown in Table 3. Typically, arbitrageurs express their levels of interest as "cheap," "mid," or "rich." In this context, "cheap" refers to favorable bond terms, precisely a high coupon rate and a low conversion premium within the matrix, yielding the convertible's highest value. The mids would relate the midpoints of the ranges for the coupon rate and the conversion premium.

An arbitrageur will naturally seek to acquire more bonds if the terms are particularly advantageous. However, if the company prices the convertible bond at the cheap end, it may indicate

[6] The point is that the Kosmos convertible bond is attractively priced, given the market inputs. As discussed in footnote 4, in the real world, convertible arbitrageurs often use subjective inputs for volatility and credit, relying on the market estimates of these inputs as guidelines only. Doing so, however, involves more than just an arbitrage investment but also an investment view on volatility, credit, or both.

weak market demand. Consequently, if the arbitrageur naively requests a large allocation at the cheap end, they may receive a larger allocation than desired. A weak market response to the new convertible bond issue, where the arbitrageur requests and gets a large allocation, also suggests that the arbitrageur is more optimistic about volatility and credit spread than other market participants. To mitigate this risk, arbitrageurs monitor the "book color," which is the feedback and interest levels from other investors throughout the day, to gauge demand. This market feedback aids arbitrageurs in making informed decisions about the quantity of bonds to bid on.[7]

In the case of Kosmos, this investment valuation process took place on March 5, the day after the company announced the convertible bond offering. The arbitrageur informs the investment bank of their desired allocation by the close of trading that day or shortly afterward. The investment bank then reveals the final terms and investor allocations to arbitrageurs and long-only investors, usually before the market opens the following trading day. The company also issues a press release with the final terms to the public.

Despite a steep decline in Kosmos' stock price on March 5, investor interest in the new issue was high, resulting in management and the investment bank deciding to upsize the offering from $300 million to $350 million. Additionally, the investment bank received an option to purchase an additional $50 million of the new convertible bonds, bringing the total offering size to $400 million. As previously noted, Kosmos based the conversion premium on the "settled" price of $5.40 on March 5 rather than the pre-announcement price of $6.01 from the prior day. Given that the new convertible bonds are priced attractively under most scenarios, it is unsurprising that demand was high, leading to the upsizing of the issue amount. Considering our hypothetical arbitrageur's pricing of the convertible bond and their knowledge of the book color, assume that they placed a demand for 8,000 bonds ($8 million in par value) with the investment bank, irrespective of whether the bonds were priced on the "cheaps," "mids," or "rich" end of the spectrum.

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[7] Note that considerable noise exists regarding book color, and the quality of the book color is primarily driven by the arbitrageur's relation with the bank. Some banks will be less willing to detail the book's composition (arbitrage vs outright demand, what they view as "fluffed" orders, etc.) than others.

In conjunction with the investment bank, Kosmos management set the coupon rate at 3.125% and the conversion premium at 30%, with the coupon set at 0.125% above the midpoint and the conversion premium set at the midpoint. The final valuation estimate for the new convertible was 103.84 based on the arbitrageur's proprietary volatility and credit spread inputs versus 102.37 based on the investment bank's inputs, slightly above the valuations at the midpoints of each input range.

Assume the arbitrageur received an allocation of 5,000 bonds of the requested 8,000 and learns of their allocation shortly before the market opens on March 6. Effectively, the arbitrageur is paying $5 million to purchase $5,192,000 (calculated model valuation based on the arbitrageur's proprietary volatility and credit spread inputs) of new convertible bonds, thus acquiring them at less than their fundamental value. However, arbitrage has yet to occur; instead, the arbitrageur has only entered a long position by purchasing a convertible worth less than its intrinsic value. The pure definition of arbitrage is purchasing a security simultaneously with the short sale of an equivalent security, thereby locking in a risk-free profit. In this "textbook" definition of arbitrage, the convertible arbitrageur would purchase the 5,000 convertible bonds for $5 million and simultaneously sell 5,000 equivalent convertible bonds for a total price of $5,192,000, thereby locking in a risk-free profit of $192,000.

In the real world, however, arbitrage is far from risk-free; otherwise, potential arbitrage opportunities would not exist. The hypothetical arbitrageur is not merely shorting an equivalent 5,000 Kosmos convertible bonds at 103.84 but will attempt to create the arbitrage trade with a hedge of similar, as opposed to equivalent, securities, specifically, the underlying stock, and will need to do so expeditiously to lock in the cheapness of 3.84% of the newly issued convertible. When trading opens and before the hedge is on, the allocation leaves the arbitrageur temporarily unhedged, long the convertible, and a decline in the underlying stock can erase the expected profit before the hedge is in place.

Below, we describe the steps of hedging the convertible bond via shorting the underlying shares of Kosmos. We also note that some arbitrageurs may pre-hedge their convertible bond via shorting shares of Kosmos during the prior day, albeit with risk as well. Other arbitrageurs may initially establish a market hedge by shorting S&P 500 futures once they receive their allocation, for liquidity reasons. They then switch from the market hedge to the direct hedge by shorting Kosmos shares commensurate with removing the market hedge. We will discuss these alternative strategies after providing the details behind putting on a direct hedge upon receiving the allocated bonds.

Table 4: Bloomberg Convertible Pricing Model Output for Kosmos Energy

Bond ZD4828947 Stock KOS US Equity

11) Pricing Analysis | 12) Cash Tender | 13) Historical Analysis | 14) Scenario Analysis | 15) Nuke/Hedge

21) Analysis | 22) IR Curve | 23) Credit Curve | 24) Dividends | 25) Volatility

Market Price	Spread (OAS)	Volatility	Stock Price	Borrow Cost
100.000	630.000	44.50	5.400	0.0 %
	User Flat Credit	User Flat		

Trade Date	Settle Date	Model	E2C	Greeks based on
03/05/2024	03/05/2024	Black-Scholes	0.0	Spread & Vol

Fair Value	105.773	Bond Floor	68.016	IR Sens	-2.107	Yield to Mty	3.125
Cheapness (%)	5.458	Option Value	37.757	Spread Sens	-2.173	Yield to Call	N.A.
Implied Spread	933.966	Parity	76.923	Phi	N.A.	Yield to Put	N.A.
Implied Vol	31.046	Premium (pts)	23.077	Psi	-2.050	Yield to Worst	3.125
Delta (%)	77.872	Premium (%)	30.000	Chi	N.A.	Current Yield	3.125
Delta (pts)	0.599	Gamma	0.272	Upsilon	0.000	Breakeven (Y)	7.385
Effective Trig	144%/10...	Vega	0.418	Convexity	0.193	CF Payback (Y)	7.385
Unit Prc	1.058M	Theta	0.009	Effective Dur	1.992	Accrued Int	0.000
Hedge Ratio	11.093	Exp Life (Fugi...	4.837				

Description

Bond CUR	USD	Conv Prc	7.0200	Issue Amt	400.00MM	Next Call Date	None
Stock CUR	USD	Conv Ratio	142.4501	Amt Out	400.00MM	Next Put Date	None
Stock Ticker	KOS US	Proj Conv Ratio	142.4501	Issue Date	03/08/24	Next Call Price	None
Cusip	500688AG1	Init Prm (%)	30.00	Maturity	03/15/30	Next Put Price	None
Collateral	COMPANY GUAR...	Coupon	3.125% FIXED	Conv From	07/01/24	Prov Trig	130%/9.126
Par Amount	1000.00	Cpn Freq	Semi-Annual	Conv Until	03/13/30	Prov Start	03/22/27
ISIN	US500688AG18	First Coupon	09/15/24	Day Count	ISMA-30/360	Prov Addl Points	23.0769

Source: Bloomberg.

As shown in Table 4, the Bloomberg image displays various inputs we have previously described, such as the $5.40 stock price, which was the last available price for Kosmos when the arbitrageur received their new issue allocation on the morning of March 6, before the market opened.[8] It also reports key outputs for the Kosmos convertible bond, including the delta estimate. Delta measures the sensitivity (partial derivative) of the convertible bond to the underlying stock:

$$\text{Delta} = \Delta = \frac{\text{Change in Convertible Price}}{\text{Infinitesimal Change in Stock Price}}$$

The delta estimate is 77.9%, suggesting that a 1.00% change in Kosmos's price will result in an approximate 0.78% movement of the convertible bond price in the same direction. Several factors influence this estimate, including the current stock price, the conversion ratio, the coupon rate, the term structure of interest rates, the issuer's credit spread and volatility, as well as the specific pricing model.

[8] A careful reader may note that the fair value of 105.77 in Table 4 differs from the 103.84 final valuation estimate indicated earlier. The 103.84 estimate is output from the pre-issue Bloomberg pricer, which makes certain assumptions about the make-whole tables, which are unknown at the time of issuance. A make-whole table indicates the compensation, via a higher conversion ratio, which results in the case that the life of the convertible bond ends prematurely due to a cash merger for instance. The pre-issue pricer provides an approximation of the make-whole table, which can differ substantially from the final official table (reflected in Table 4's output).

To translate that sensitivity into a stock hedge, think in "share-equivalents": each bond embeds exposure to the conversion ratio (shares per bond); scaling that exposure by delta gives the adequate equity exposure of one bond. The equation for the number of shares required to hedge a convertible bond is:

$$\text{Shares to Hedge} = \text{Number of Bonds} \times \text{Conversion Ratio} \times \Delta$$

Recall that the arbitrageur received an allocation of 5,000 convertible bonds, but for this illustration, we begin by assuming 1,000 bonds (face value of $1 million). The Bloomberg image indicates a conversion ratio of 142.4501, calculated as:

$$\text{Conversion Ratio} = \frac{\$1{,}000}{\text{Conversion Price}}$$

Where the conversion price is $7.02, reflecting the 30% premium over the $5.40 closing price on March 5, 2024. To insulate the convertible bond from movements in Kosmos' stock price, the arbitrageur will short 110,929 shares, creating a total short position of $599,015.[9] However, the arbitrageur does not simply establish the short position of 110,929 shares immediately when the stock market opens, as it can take hours to implement the hedge without putting excess downward price pressure on the Kosmos stock price. As noted at the beginning of this article, when corporations announce a convertible bond issuance, the underlying stock price declines 2-3%, on average, partly due to the expected price pressure resulting from the subsequent shorting of issuers by arbitrageurs seeking to hedge their long positions in the new convertible bonds. The longer the arbitrageur takes to sell the underlying stock short, the greater the risk of eroding the expected arbitrage gains due to not having the proper hedge in place.

One way to reduce, though not eliminate, this hedge mismatch due to the time it takes to institute the stock hedge is to sell S&P 500 futures contracts immediately upon receiving the bond allocation. The primary benefit of selling S&P 500 futures is that they are highly liquid; thus, the arbitrageur will not bear the price pressure risk. Like the direct stock hedge, this market hedge will account for the number of bonds received and the delta estimate; additionally, the market hedge

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[9] Importantly, the delta itself does not determine the hedge ratio. Delta measures the sensitivity of the convertible bond's price to a marginal change in the underlying stock price. Translating that sensitivity into a stock hedge requires scaling by the conversion ratio, which determines the number of shares embedded in each bond.

should reflect the beta estimate of the underlying stock relative to the S&P 500. Based on weekly data during the three years before the announcement of the convertible issue, Kosmos's equity beta is 1.00 relative to the S&P 500. Thus, the arbitrageur would sell an equivalent market value of S&P 500 futures as the intended short position in the stock price of Kosmos. Suppose, instead, the beta for Kosmos was 1.25. In this case, the arbitrageur would sell 125% in value in S&P 500 futures to the value of their intended short position in Kosmos stock. The S&P 500 hedge protects the investment against systematic stock market movements but not against idiosyncratic movements in Kosmos. As the arbitrageur implements the direct stock hedge, they will simultaneously reduce the exposure of the S&P 500 hedge, attempting to maintain a market-neutral position throughout the process.

Rather than waiting to receive their allocation before hedging the convertible bond, many arbitrageurs hedge in advance to avoid overnight market risk with a short position in the underlying stock or with S&P 500 futures. In both cases, the arbitrageur will estimate the allocation of convertible bonds they expect and then hedge accordingly. There are costs and benefits to each approach. The direct stock hedge is cleaner, as the arbitrageur will need to establish a delta hedge, and doing so in advance may result in better execution than waiting until the bond comes to market, given the potential for continued price pressure on the issuance date. The downside of this approach is that it carries direct equity risk on the day in question, as the equity could trade up towards the end of the day, for instance, if the issuer pulls the deal or if the stock market moves significantly higher. Whereas, as discussed above, the arbitrageur is initially just long a convertible bond as opposed to a convertible arbitrage position, when pre-hedging with the underlying stock, the arbitrageur temporarily has only a short position in the underlying stock as opposed to a hedged convertible arbitrage position.

The approach of pre-hedging with a market hedge, such as selling S&P 500 futures, can mitigate the price pressure attributed to arbitrageurs who pre-hedge with the underlying stock. It can also eliminate intraday equity risk, as futures trade up to an hour after the equity markets close. In addition, this approach has the additional benefit of potentially securing a better allocation as corporate executives prefer outright investors in new convertible debt issues, and funds that hedge initially via futures often qualify as such. As discussed above, the downside of this approach is that hedging with a market index still leaves the arbitrageur exposed to idiosyncratic stock risk. Lastly, the arbitrageur does not have to think that these are mutually exclusive ways to hedge, that is, before or after the allocation, and either the initial hedge with the stock or stock index futures, as it is often feasible to combine these approaches.

The Bloomberg image in Table 4 also shows alternative ways to communicate the level of cheapness or richness of the convertible bond. For example, holding all other inputs constant, including the 44.5% volatility estimate, the implied credit spread for the convertible is 934 basis points. Thus, if the hypothetical arbitrageur assumed the credit spread for the Kosmos convertible bond was 934 basis points, the fundamental value for the convertible bond would be 100.00, pricing it precisely fair. Therefore, assuming a credit spread of 630 basis points, there is approximately a 300-basis-points cushion before the convertible prices at par. Alternatively, the implied volatility is 31.0%. If the arbitrageur assumed a volatility estimate of 31.0%, along with the other respective inputs unchanged, the convertible bond would have a fundamental value of 100.00, thus equal to the par value. If the volatility exceeds 31.0%, the convertible bond will be issued at a price below intrinsic value, especially with a volatility estimate of 44.5%, well above the 31.0% implied volatility estimate.

It is also worth noting that in some situations, the company will conduct a concurrent share repurchase to facilitate short selling of the underlying stock by arbitrageurs. In these cases, hedge funds receiving allocations in the convertible bond offering will short sell shares directly to the company as a part of the new issue process. This direct transaction with the issuer reduces the risk for the arbitrageurs and lessens price pressure on the stock, which is viewed positively by the issuer. The Kosmos new convertible issue included a concurrent share repurchase.

Following the allocation and initial hedging process, the convertible bond trades like any debt security in the secondary market. Most convertible bonds commence trading as an unregistered security, restricting purchases only by qualified institutional buyers (QIBs). The bonds typically transition from an unregistered to a registered security within 90 days, after which all market participants can purchase them. The bond indenture specifies the exact time frame of this transition. It can trigger an event of default if not correctly handled, as was the case with Avid Bioservices in March 2024.[10] We next discuss secondary trading in convertible bonds.

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[10] Avid Bioservices issued a convertible note in 2021 with a maturity in 2026. As with most new convertible issues, the Avid Bioservices convertible bond initially started trading as an unregistered security, which restricted which

3. Convertible Trading (and Hedging) in the Secondary Market

Secondary Trading

In the secondary market, convertible bond trading centers on two core activities: identifying mispriced issues and managing the associated hedges. The first core activity in the secondary market, as in the new-issue market, is to identify convertible bonds trading at a significant discount, enabling arbitrage profits. Similarly, the arbitrageur will identify convertible bonds that trade at reliably rich prices; here, the arbitrageur will sell rich convertible bonds held in their portfolio and consider shorting rich bonds not in their existing portfolio. The second core activity involves hedging not only the new positions to the portfolio and removing hedges when subtracting positions from the portfolio but also dynamically hedging the existing portfolio due to changing economic conditions, particularly changes in the stock prices of the underlying equities.

Arbitrageurs focus on finding consistent, reliable opportunities to buy assets at a lower price, rather than simply looking for assets that are cheap in an absolute sense. Positions with stock prices well above the conversion price (equity-sensitive) are usually more hedgeable and thus merit higher weights than equally "cheap" busted convertibles that are primarily credit-sensitive. Using the same valuation framework as the Kosmos new-issue example, arbitrageurs initiate new positions or add to under-weight holdings where convergence to fundamental value is most reliable. As we will discuss later, the hedging efficiency of an equity-sensitive convertible bond is significantly greater than that of a more credit-sensitive convertible bond.

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market participants could trade the bonds and had a provision in its indenture stating that if the company failed to transfer the bonds to a registered security within 370 days, then the bonds would accrue additional interest to the bondholders. As of February 29, 2024, Avid Bioservices had not paid the accrued interest, and the bond remained tied to its unregistered status. An astute investor purchased over 25% of the issue in February 2024 and then served an acceleration notice to the company, resulting in the bonds immediately coming due. The convertible bond was well out of the money and traded at 78.97 on February 1, 2024, relative to a stock price of $6.59 and a conversion price of $21.23. Throughout February 2024, the bond's price steadily climbed on above-average volume, closing at 89.35 on February 28. The first reported trade after the public dissemination of the technical default was on March 7, when the bond traded at 101.01, reflecting the par value paid on default plus default interest.

When an arbitrageur buys a convertible bond in the primary market, a timing mismatch occurs when establishing a short position in the underlying stock as a hedge. This mismatch arises because the arbitrageur cannot purchase the convertible bond and execute the stock hedge. In the secondary market, however, the arbitrageur typically buys or sells the convertible bond while simultaneously setting up or unwinding the short position on the underlying stock. As described below, sell-side trading desks facilitate these arbitrage transactions by making markets in convertible bonds while accounting for the desired associated short positions in the issuer's stock.

Sell-side trading desks quote convertible bonds based on their "delta" in their market-making operations. For example, a sell-side convertible trading desk might quote a hypothetical convertible bond at 121.25 – 121.75 with a delta of 0.68 relative to an underlying stock price of $24.17.[11] Quoting convertible bonds on a delta basis helps reduce uncertainty about the bond's price due to fluctuations in the underlying stock price between the time of the quote and the execution of a trade. Additionally, sell-side desks often hold the bond at that delta in their inventory. This practice enables convertible arbitrageurs to mitigate the timing risk associated with executing the transaction in two separate steps—buying the convertible bond and establishing the delta hedge. Instead, the arbitrageur can manage the purchase or sale of the hedged convertible bond in a single transaction, streamlining the process and mitigating risk.[12]

In the primary market, when a new convertible bond is issued, the issuer and its investment bank typically price the convertible at an attractive price to encourage convertible investors to purchase the new issue. In many cases, once the new convertible bond begins trading in the secondary market, its price quickly converges to or near its fundamental value. There are also frequent instances in which the

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[11] For added context in this example, the sell-side desk offers to buy the convertible bond at 121.25 and sell it at 121.75. These quotes typically include details on the number of bonds available and the desk's willingness to transact at the specified quotes.

[12] It's important to note that a convertible arbitrageur purchasing a bond may need to adjust the delta based on different inputs, such as volatility and credit spread estimates, which can affect the delta calculation. This adjustment may involve shorting additional shares of the underlying stock or repurchasing shares from the convertible bond arbitrage package. These delta adjustments are typically modest, usually within five delta points or less.

market valuation of the new convertible bond, while increasing in value after issuance, remains below its fundamental value for a lengthy period.

Once it starts trading in the secondary market, the cheapness level of a convertible bond is primarily a function of two factors: the overall market conditions for convertibles and the liquidity of the new issue. The general level of cheapness in the convertible bond market will influence the secondary market pricing of new convertible issues. If convertible bonds are trading on average around 2% below their fundamental values, the latest convertible bond will also trade around 2% below its fundamental value, with adjustments for any unique characteristics. Second, liquidity plays a critical role in the persistent cheapness of some convertible bonds. Whereas the fundamental valuation should determine the convertible bond's price, illiquid convertible bonds tend to trade at relatively higher discounts. This illiquidity-induced cheapness poses a more difficult challenge for arbitrageurs with short investment horizons, for example, due to potential investor redemptions or withdrawal of financing by their prime brokerage lenders. If an arbitrageur becomes a forced seller of their convertible arbitrage portfolio, the illiquid convertibles are the most difficult to trade out of without substantially reducing prices. For example, during the Great Financial Crisis of 2008, illiquid convertible bonds experienced extraordinary increases in their levels of cheapness to fundamental values, with increases in cheapness more than double those of liquid convertible bonds.

Aside from lack of liquidity or prevailing market conditions, a convertible bond can also cheapen in the secondary market due to various catalysts that reduce demand among certain investor groups, such as long-only investors. Many long-only investors prefer holding convertible bonds, which offer a balanced exposure to debt downside protection and equity upside optionality. However, if the underlying stock price rises significantly and becomes deeply "in the money," the equity component of the bond becomes more dominant, making the convertible more like a stock than a balanced blend of debt and equity. In such cases, long-only investors with mandates to hold balanced convertible bonds will reduce their holdings of this convertible bond, which becomes equity-like. This simultaneous reduction in demand can result in a cheapness expansion and thus an entry opportunity for the convertible arbitrageur, who can take advantage of the temporary supply-and-demand imbalance by purchasing the "cheap" convertible bond and hedging the associated risks, as we described earlier.

Supply-and-demand imbalances in the convertible bond market are not necessarily one-sided and driven by selling pressure. For example, under various economic and market conditions, a specific convertible bond could suddenly become highly attractive to convertible investors, leading their buying pressure to push the convertible price above its fundamental value, that is, to trade “rich.” For example, a catalyst would be adding the convertible bond to an index, causing index-driven convertible investors to add the bond to their portfolios at roughly the same time as they attempt to minimize the tracking error of their portfolios to the respective convertible bond index. In this case, arbitrageurs respond to the newly rich convertible bond by selling it from their portfolios. They may even consider a short sale of the convertible bond, depending on the availability of borrowing to short it and its market liquidity. If arbitrageurs move forward to sell short the convertible bond, they will simultaneously purchase the underlying stock to hedge the position and isolate the richness. A critical factor for an arbitrageur shorting a convertible bond is to ensure that the availability of shorting the bond remains sufficient. If short availability becomes an issue, the arbitrageur may need to repurchase the convertible bond at a higher price than expected.

In perfect capital markets, arbitrage occurs instantaneously. Using the example of convertible bonds, an arbitrageur identifies a mispriced convertible bond, trading at a discount to its fundamental value. The arbitrageur immediately purchases the convertible bond and simultaneously hedges the systematic risk by shorting its "equivalent" securities, such as the underlying stock. In this textbook world, the convertible arbitrage trade is self-financing as funds from the short positions cover the cost of the long position in the convertible bond. Due to arbitrageurs’ trading activity, security prices immediately adjust to eliminate the mispricing and allow the arbitrageur to realize arbitrage profits instantly. Of course, the paradox is that if the arbitrageur could immediately capture the arbitrage profits and eliminate the mispricing without risk, the mispricing would not exist in the first place.

The real-world convertible arbitrage trade is far different. First, you must allocate capital for the position; we will address the funding of convertible arbitrage trades in Section 5. Second, real-world arbitrage trades do not generate instant profits. Suppose the arbitrageur purchases a convertible bond trading at a 2% discount with an expected life of four years. Notably, the cheapness may not converge to zero until the bond matures. Alternatively, the cheapness could converge to zero, or near zero, in a few months; thus, there is considerable uncertainty about the path to cheapness, and in fact, the cheapness could widen before eventually converging. Indeed, during periods of extreme financial market distress, such as the 2008 Great Financial Crisis, convertible bonds can become cheap enough that they result in either investor redemptions or the withdrawal of leverage by the prime brokerage lenders to the arbitrageur, forcing the arbitrageur to sell convertibles at the worst time and thus crystallizing the losses.

Because the path to convergence is noisy and can widen before narrowing, the arbitrageur must continuously update the hedge ratio. Delta hedging neutralizes most equity risk, but it leaves material sensitivity to credit, interest rates, and jumps-to-default. The arbitrageur complements the share hedge with direct credit hedges (when feasible) before turning to portfolio-level hedges; we start with the direct equity and credit hedges below.

Direct Hedging (Equity and Credit)

In the Kosmos example, the hypothetical arbitrageur shorts 110,929 shares for every 1,000 convertible bonds purchased in the new offering, given a stock price of $5.40 at the close of trading on March 5, 2024. Assume the arbitrageur completes this hedge on March 6 during regular trading hours and maintains a simple hedging policy of re-hedging the convertible position daily based on the prior day's closing prices. On March 6, the stock price of Kosmos rose slightly to close at $5.59. Assuming the volatility and credit spread inputs remained unchanged due to the minimal passage of time, the delta on the convertible bond increased from 77.9% to 78.7%, nearly an entire delta point, with the $0.19 increase in the stock price. Given the 142.4501 conversion ratio, the new hedged short position would be 112,175 shares, requiring an additional 1,246 shares to sell short. On a notional basis, the short position will increase from $599,015 to $627,058.[13]

This example illustrates how the arbitrageur would adjust the equity hedge daily using closing stock prices. Alternatively, the arbitrageur could re-hedge continuously throughout the trading day based on intraday stock price movements or less frequently, such as when there are significant changes in the underlying share price. The frequency of these hedges does not alter the expected arbitrage

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[13] Note that two inputs changed slightly while we assumed the same credit spread and volatility estimates with the $5.59 stock price on March 6 versus the $5.40 stock price on March 5. First, there is time decay in the bond's optionality, but only for one day. Since the convertible bond is well out of the money, the one-day time decay will result in a minuscule reduction in the delta estimate. Second, the term structure of interest rates may have changed slightly on March 6, which could result in another small change in the delta, positive or negative. The changes in these two input estimates reduced the delta from 77.9% to 77.3%, holding the $5.40 stock price, credit spread, and volatility estimates constant. The stock price increase from $5.40 to $5.59 without these changes would have resulted in a delta higher than 78.7%.

profits from purchasing and hedging a convertible bond priced cheaply relative to fundamental values. For example, with the 5.46% cheapness of the Kosmos convertible bond, the arbitrageur should capture profits from the convergence of this cheapness estimate regardless of the hedging frequency. However, longer intervals between re-hedging increase the volatility of total realized returns because the likelihood of the realized hedge ratios differing from the model values is higher.[14]

In addition to equity risk, convertible arbitrageurs typically hedge two common risk factors: interest rate and credit risk. Delta hedging the equity exposure of a convertible bond helps mitigate some credit and interest rate risks, as these factors are interconnected and dynamically influence the bond's value and delta. Below, we first discuss direct hedging of credit risk, followed by an exploration of portfolio hedging that considers both credit and interest rate risks while accounting for their interconnectedness.

As mentioned above, we computed a delta estimate of 77.9% for the Kosmos convertible bond using the following inputs: a stock price of $5.40, a credit spread of 630 basis points, and a volatility estimate of 44.5%. In comparison, if we assume the company has zero credit risk, thus incorporating a credit spread of 0 basis points in the pricing model, the estimated delta declines significantly to 64.6%. Therefore, the stock hedge in the Bloomberg convertible pricing model partially adjusts for credit risk, thus increasing as the credit spread increases. The arbitrageur has a few alternative methods to hedge the credit risk. We first explore the use of the issuer's securities as a hedge against credit risk and then examine a portfolio approach to mitigating credit risk.

As discussed earlier, when we used the issuer's CDS to estimate the credit spread, a liquid CDS curve provides a market-based measure of credit risk. If such a contract is available, it also offers a direct hedge. In our Kosmos example, purchasing the convertible bond leaves the arbitrageur long credit risk through the bond component. Buying CDS protection would pay out in the event of a credit occurrence, such as bankruptcy, thereby offsetting losses on the bond. The principal advantage of a

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[14] Because the expected return on equities is positive, the share price tends to drift upward between hedge adjustments. When the arbitrageur does not frequently rebalance the hedge, the actual delta on the convertible exceeds the delta used to set the hedge ratio. This imbalance creates a small net long exposure to the underlying stock—an under-hedged position.

CDS hedge is that the credit exposure can be isolated and managed independently of the equity and interest-rate exposures addressed in the delta hedge.

Suppose our hypothetical arbitrageur hedges the credit risk with a CDS. In that case, when the arbitrageur estimates the delta for the stock hedge, they assume zero credit risk in their delta calculation and thus employ the 64.6% delta, that only hedges the equity risk. However, a CDS market for Kosmos Energy did not exist at the time of its new convertible issue. CDS instruments are generally unavailable for most convertible issuers, existing primarily for large corporations that rarely issue convertibles. Even when CDS instruments are available for convertible issuers, they tend to be relatively illiquid. This lack of liquidity can make purchasing credit protection prohibitively expensive, potentially eroding the expected arbitrage profits from purchasing a cheap convertible bond and hedging its underlying equity and credit risks.

A second way to hedge the credit risk of a convertible bond directly is to establish a short position in the underlying issuer's straight debt. For example, in the case of the convertible bond issued by Kosmos Energy, the arbitrageur could attempt to short the straight debt of equal seniority that matures in four years, which we used earlier to estimate the credit spread for the convertible bond. However, if the convertible bond remains outstanding after the maturity of the four-year straight debt, the arbitrageur needs to reestablish the credit hedge. Similarly to hedging credit risk with a CDS, the arbitrageur would use the delta estimate of 64.6%, which hedges only the equity risk associated with the convertible.[15]

A significant constraint with straight debt as a hedging instrument is its illiquidity. The attempt to time the short sale of straight debt to coincide with the purchase of the convertible debt can exert significant price pressure on the straight debt if it is illiquid. In addition, the borrowing costs associated with straight debt can be extraordinarily high. Moreover, when borrowing costs are high, there can be significant buy-in risk, making it challenging to maintain the short position, especially in illiquid issues.

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[15] A short position in the issuer’s straight debt neutralizes more than just credit risk. Because the straight bond has duration, shorting it offsets much of the interest-rate exposure embedded in the long convertible bond. In contrast, a CDS provides protection only against default; it leaves the position fully exposed to movements in risk-free rates and may therefore require a separate interest-rate hedge. The following sub-section describes the mechanics of hedging the remaining interest-rate risk.

The combination of borrowing costs and price pressures from straight debt short sales can significantly diminish the arbitrage gains.

Circling back to the delta estimate of 77.9% for the Kosmos convertible, where the pricing model accounts for the credit spread of 630 basis points, the additional delta points versus the 64.6% delta estimate hedge the credit risk against slight declines in the value of Kosmos but not in large jumps, such as an immediate jump to default. Some arbitrageurs hedge this jump-to-default risk by taking on additional equity shorts, often referred to as “additional deltas.” However, there is no industry standard for determining the precise amount, and practitioners usually adopt an ad hoc approach, such as arbitrarily adding 5 delta points to the theoretical deltas. A significant drawback to this hedge is that while it provides added downside protection, it will also generate losses with stock price increases.

Portfolio Hedging of Credit and Interest-Rate Risk

Above, we focused on transaction-level hedges for equity and credit exposure. Delta-hedging the stock component remains the cornerstone of convertible arbitrage, and in addition, dampens some of the bond’s credit- and interest-rate sensitivity. In practice, however, shorting a straight bond or buying a CDS to hedge the residual credit exposure is often impractical because these instruments may be illiquid or unavailable. A workable alternative is to treat credit and interest-rate risk as portfolio-level factors and hedge them accordingly. By regressing historical, delta-hedged convertible-arbitrage returns on systematic credit and interest-rate variables, an arbitrageur can estimate the portfolio's sensitivity to these risks and size hedges to mitigate the strategy's exposure to future shocks.

The starting point for the regression analysis is a return series, such as monthly returns, of a delta-hedged convertible arbitrage portfolio, ideally over several business cycles. The benefit of a long series of portfolio returns is that it enables a more accurate assessment of the impact of credit and interest-rate shocks on a convertible-arbitrage portfolio. The composition of the convertible bond portfolio influences its reaction to changes in interest rates and credit spreads, considering the equity hedge in place. Consider a portfolio of deep-in-the-money convertible bonds, where the average underlying stock price is approximately 150% of the conversion price. A portfolio with high moneyness, and therefore high delta, will behave more like equities and exhibit relatively low sensitivity to systematic credit and interest-rate risk. In contrast, a portfolio of busted convertible bonds, in which the underlying shares have declined significantly after issuance, will exhibit high interest-rate and credit-risk sensitivity, even with a delta hedge. Such a portfolio behaves more like straight debt with substantial credit and interest-rate exposure.

A practical approach to accounting for differences in portfolio composition is to categorize convertible bonds according to their moneyness. Bonds in lower-moneyness categories tend to have higher sensitivity, or loadings, to interest-rate and credit risks than those in the high-moneyness categories. The regression analysis will illustrate these risk loadings on the convertible arbitrage portfolio. Assume for the discussion below that the arbitrageur uses the monthly return on five-year U.S. Treasury bonds to capture interest-rate risk and the returns to a high-yield bond index (less the returns to five-year U.S. Treasury bonds) to capture systematic credit risk.

Suppose these credit and interest-rate return measures exhibit an economically and statistically significant positive impact on the monthly returns of a busted convertible arbitrage portfolio. In that case, they instruct us on the magnitude of under-hedging by the portfolio and, similarly, the amount of hedging required to minimize the portfolio's exposure to these systematic risk factors. Assume, for example, that a historical portfolio of low-moneyness and thus busted convertibles has a beta coefficient of 0.30 relative to the return stream of five-year U.S. Treasury bonds. On average, this portfolio of busted convertibles yields 0.30% for every 1.0% increase in five-year U.S. Treasury bond returns. To hedge this interest-rate exposure, the arbitrageur could implement a $300 million short position in five-year Treasury futures for every $1 billion in long market value of busted convertibles. A key assumption in this approach is that the current convertible arbitrage portfolio of distressed convertibles will respond to Treasury bond returns in a manner consistent with the historical experience analyzed in the regression.

Like the portfolio-level hedging of interest rate risk, if the returns of a delta-hedged convertible arbitrage portfolio vary positively with the returns to a high-yield credit index (minus the corresponding return on treasuries), the arbitrageur can attempt to offset this residual credit risk with a portfolio credit hedge. A potential portfolio hedging instrument for credit is a CDS index that tracks a basket of single-issuer CDSs. Since convertible issuers are predominantly high-yield rather than investment-grade, an arbitrageur could purchase protection on a CDS index basket comprising high-yield names.

Though not as liquid as treasury futures, a CDS index exhibits greater liquidity than its underlying constituents, and thus, concerns such as price pressure are less prevalent. However, this approach also carries significant basis risk as there is generally limited overlap between the issuers in the CDS index and those in the convertible arbitrage portfolio. While the CDS index hedge can adequately shield the convertible arbitrage portfolio from systematic credit events, such as a sudden economic downturn, it does not protect the portfolio against an idiosyncratic credit event, such as a random default by an issuer within the convertible arbitrage portfolio not represented in the CDS index.[16] In these instances, the portfolio credit hedge does not protect the convertible arbitrage portfolio as intended.

A feature of credit hedges is that they inherently exhibit "negative gamma," regardless of whether the shares of the underlying issuer or a CDS index serve as the credit hedge instrument. Consider our hypothetical arbitrageur who purchased the Kosmos convertible bond. Suppose Kosmos experiences a severe negative shock, causing its stock price to drop in half. As the convertible bond declines in value commensurate with the stock price, the credit exposure increases significantly, so that the residual credit risk not accounted for by the stock hedge begins to rise. As a result, the arbitrageur increases the credit hedge by either adding more delta points or by increasing the amount of the CDS index hedge.

If the arbitrageur relies on additional delta points to mitigate the credit risk, they will short more shares as the stock price declines. Then, if the stock price increases, they repurchase the shares at higher prices, and so forth. This behavior mirrors the concept of gamma when the convertible bond is more equity-sensitive, which is inherently positive, like a call option, rather than the negative gamma effect observed here. This issue also applies to hedges based on a CDS index, where the index price decreases when credit tightens and increases when credit widens. Here, the arbitrageur reduces the credit hedge with the CDS index when the price of credit protection decreases and increases it when the price of credit protection rises, resulting in negative gamma.

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[16] Even if an issuer in the convertible-arbitrage portfolio appears in the CDS index, the index hedge may still be inadequate because it is based on the issuer's index weight, not its portfolio weight. If the portfolio holds a larger position in a name than its index weight, the CDS index will under-hedge that idiosyncratic default risk; if the position is smaller, it could be over-hedged. This mismatch underscores the residual basis risk inherent in index-based credit hedges.

4. Delta Hedges and Moneyness

The Kosmos discussion in Section 2 highlighted how changes in the underlying issuer's stock price affect the delta hedging of convertible bonds. Additionally, we described in Section 3 indirect hedging instruments, such as treasury futures and CDS indexes, which are helpful when convertible bonds become more sensitive to interest rates and credit risks. To illustrate the significant variation in hedging strategies across convertible bonds, this section analyzes two convertible bonds: a low-moneyness bond issued by Snap, Inc., and a high-moneyness bond issued by MakeMyTrip, Ltd., both priced as of September 30, 2024.

On February 11, 2022, Snap, Inc., a social media platform company, issued $1.5 billion of convertible bonds with a coupon rate of 0.125% and a conversion premium of 50% relative to the pre-issue stock price of $37.56, resulting in a conversion price of $56.34. Despite the low coupon rate and high conversion premium, Snap sold the new convertible issue to arbitrageurs and convertible long holders without difficulty. However, the subsequent months saw a significant decline in the share prices of social media companies, including Snap Inc.'s. By September 30, 2024, Snap's stock price had declined to $10.70, resulting in a moneyness of just 0.19, well below the conversion price of $56.34.

MakeMyTrip, Ltd. (MMYT), an online travel company based in India and listed on the NASDAQ, is the issuer of our high-money convertible bond example. In February 2021, MakeMyTrip issued a zero-coupon $200 million convertible bond with a conversion price of $38.75, a 35% premium to its prior close of $28.70. While MakeMyTrip's stock price spent much of 2021 and 2022 trading within a tight range, its prospects shifted positively in the second half of 2023, coinciding with the broader growth of India's stock market. As a result, by September 30, 2024, the equity was trading at $92.95, well above its convertible bond conversion price of $38.75, with a moneyness level of 2.40, which is over 12 times Snap Inc.'s convertible bond moneyness level.

The stark contrast in moneyness levels between the two bonds underscores the different hedging strategies a convertible arbitrageur might use. Table 5 presents the key inputs and outputs for our analysis of the respective hedging strategies employed by these two convertible bonds. We begin with MakeMyTrip. Our estimate of MakeMyTrip’s annual volatility is 40%. The credit spread estimate is

100 basis points, comparable to firms with bond ratings slightly below investment-grade.[17] MakeMyTrip has a market capitalization of more than $10 billion, and its only outstanding debt is the $200 million convertible bond. MakeMyTrip has a negative net debt position, with a cash balance of over $700 million, and generated nearly $200 million of cash flow in 2024.

Table 5: Comparison of Convertible Model Inputs and Outputs for MakeMyTrip, Ltd. and Snap, Inc.

	MakeMyTrip, Ltd.	Snap, Inc.
Convertible Bond Price	242.50	80.02
Underlying Stock Price	92.95	10.70
Conversion Ratio	25.80	17.75
Conversion Price	38.75	56.34
Moneyness	2.40	0.19
Parity	239.84	18.99
Assumed Credit Spread	100 bps	100 bps
Assumed Volatility	40%	50%
Model Value	243.67	87.50
Model Cheapness	0.48%	8.55%
Model Delta	0.97	0.03
Long Value	2,424,990	800,220
Short Value	2,326,482	5,698
P&L in Default Scenario	51,492	-644,522

Source: Bloomberg Convertible Pricing Model and user inputs.

Using the Bloomberg convertible pricing model and the above-described inputs, the estimated value of the MakeMyTrip convertible bond as of September 30, 2024, is 243.67 compared to a market price of 242.50, resulting in a 0.48% discount. For this discussion, our primary interest is the delta estimate of 0.97, which is consistent with our expectations as the convertible is deeply in the money and

[17] As with our analysis of Kosmos Energy, we provide volatility and credit spread estimates commensurate with the market's expectations of those inputs. Also, while a credit spread of 100 basis points might appear unusually low, credit spreads were at a multi-year low in late 2024. For example, investment-grade spread indexes were around 85 during this period, the lowest since 2005, and high-yield credit spread indexes were below 300, the lowest since 2007.

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behaves more like an equity substitute than the typical convertible bond. Assume the arbitrageur purchases 1,000 convertible bonds for a total purchase price of $2,429,990. Given the delta estimate of 0.97, the value of the short hedge in MakeMyTrip's stock is $2,326,482:

$2,326,482 = 25.8035 conversion ratio × $92.95 stock price × 0.97 delta × 1,000 bonds

As displayed in Table 5, the MakeMyTrip convertible bond's conversion value (or parity value) is 239.84, only 1.6% less than its fundamental value of 243.67. For the arbitrageur, the value proposition of MakeMyTrip's convertible bond is in its embedded option. Indeed, the cheapness level is far more sensitive to the volatility estimate than the credit spread estimate. The implied volatility is 36.6%, not far below the 40.0% volatility estimate we used to model its cheapness. In contrast, the credit spread estimate requires a significant increase from 100 basis points to 411 basis points to drive the fundamental value of the convertible to its current market price.

In the context of Figure 1 at the beginning of this article, MakeMyTrip's convertible bond would sit firmly in the "equity-like" region (IV), with the convertible's parity and market value nearly converging at a moneyness of 2.40. Conversely, Snap's convertible bond falls into the "distressed" region (I) due to its low moneyness of 0.19. Typically, convertible bonds in the "distressed" region have a high expected probability of default due to the steep decline in the issuer's share price, which drops the convertible bond's moneyness to a low level, and the convertible thus tends to trade at depressed levels, often less than half of its par value.

Despite Snap’s precipitous stock decline following its new issue, which left its convertible bond with low moneyness, Snap remains far from financial distress, unlike most low-moneyness convertible bond issuers. It maintains a market capitalization of approximately $18 billion and positive cash flow projections for 2024. Like MakeMyTrip, we assume a 100 basis point credit spread for Snap, comparable to firms with slightly below investment-grade credit ratings. Our annual volatility estimate for Snap is 50%. Usually, the credit spread would be several times higher for a distressed convertible bond. But in the case of Snap, the primary characteristic that its convertible bond shares with other convertible bonds in the "distressed" bucket is that Snap’s stock price declined substantially after the issue of the convertible, in large part due to a steep decline in social media stocks in general, but since Snap remains a large market capitalization firm with a low-leverage balance sheet, its credit did not become impaired like most low-money convertible issuers.[18]

Using a credit spread of 100 basis points and an expected volatility of 50%, the calculated value of Snap's convertible bond is 87.50, compared to its market price of 80.02 on September 30, 2024, indicating that the bond trades at 8.55% below its fundamental value. The delta estimate for this bond is only 0.03, starkly contrasting with the 0.97 delta estimate for MakeMyTrip's convertible bond. This low delta means the value of the short hedge is minimal, amounting to just $5,698:

$5,698 = 17.7494 conversion ratio × $10.70 stock price × 0.03 delta × 1,000 bonds

Snap's convertible bond behaves more like a straight debenture than a typical convertible bond, primarily influenced by credit spread and interest rate fluctuations rather than volatility, unlike what we observed with MakeMyTrip.

The dependency on the credit spread versus the volatility estimate for the Snap convertible bond is evident when considering changes in input assumptions. For instance, raising the credit spread from 100 to 370 basis points would extinguish the bond's 8.55% cheapness, indicating the significant impact of credit risk on its valuation. On the other hand, reducing the volatility estimate from 50% down to 0% has an almost negligible effect, as the option component of Snap's convertible bond contributes only 0.72 to the total value of 87.50. For example, with a credit spread of 100 basis points, the convertible bond's cheapness drops only a relatively small amount from 8.55% to 7.79% if we assume a volatility of zero as opposed to 50%. This distinction underscores that Snap's convertible bond is essentially a straight bond with a minimal-value out-of-the-money call option.

Consider the implications of an abrupt default where both Snap and MakeMyTrip face a complete wipeout of the common equity, and the convertible bonds achieve a recovery value of 15% of

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[18] Consider that the market capitalization of Snap exceeded $60 billion when it announced the convertible bond issuance. With a market capitalization of this enormous amount at issuance, Snap is still a large-cap firm even after a stock price decline of more than 70 percent.

face value.[19] Suppose an arbitrageur holds 1,000 Snap convertible bonds with a market value of $800,220 and maintains a 0.03 delta hedge. In that case, they will suffer a significant loss of $644,522 or 80.5%.[20] The outcome for an arbitrageur holding 1,000 MakeMyTrip convertible bonds is notably different. Despite a $2,274,990 loss on the long position in the convertible bond, the arbitrageur benefits from the significant gain on the short position in the underlying stock, amounting to $2,326,482, assuming the stock price declines to zero. Here, the arbitrageur realizes a net profit of $51,492. These examples illustrate the effectiveness of the equity hedging instrument for a high-moneyness versus a low-moneyness convertible bond.

Given the assumptions, the Snap convertible is reliably cheap at 8.55%. However, how would an arbitrageur isolate the cheapness, hedging its credit and interest rate risk? Conceptually, as discussed earlier, the arbitrageur could short Snap's existing straight debt, ideally trading at the assumed credit spread of 100 basis points, thereby locking in the 8.55% cheapness. However, Snap has no straight debt in its capital structure that the arbitrageur could use to hedge their long position in the convertible bond. Likewise, there were no CDS contracts available in Snap that the arbitrageur could use to hedge Snap's credit risk.

In the absence of a direct hedge for the Snap convertible bond, the arbitrageur could implement a market-wide credit hedge by purchasing an investment-grade CDS index, thereby mitigating market-driven movements in Snap's credit spread, leaving the arbitrageur exposed only to idiosyncratic tightening and widening of the firm's credit. That is, in the event of a default on its debt by Snap, Inc., the investment-grade CDS index yields minimal benefit unless the entire investment-grade market experiences similar default outcomes. Indeed, Snap could default as the credit spread on investment-grade bonds tighten, thereby exacerbating the arbitrageur's loss.

In addition to credit risk, the Snap convertible bond is subject to considerable interest rate risk, given that it is currently far out of the money and thus nearly identical to a straight debt instrument.

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[19] In both examples, there is no debt with a higher priority than the existing convertible debt. If secured debt accounted for a high proportion of the debt in the capital structure, a bankruptcy filing typically wipes out, or nearly wipes out, the convertible debt.

[20] Specifically, the arbitrageur would realize a loss of $650,220 on the long position ($800,220 - $150,000) and a gain of $5,698 on the short position for a net loss of $644,522.

According to the Bloomberg convertible pricing model, a 1.00 percentage point increase in interest rates will cause the value of the Snap convertible bond to decline by 2.58%. In comparison, the value of a five-year Treasury bond will decrease by 4.31% in response to the same rise in interest rates. Thus, the arbitrageur seeking to hedge the interest-rate risk associated with the convertible bond fully would short the equivalent of 60% ($525,000) of the convertible bond's fundamental value using five-year Treasury futures.

With this interest-rate hedge in place, as well as the small stock hedge regarding the minimal equity optionality associated with the convertible, the arbitrageur looking to purchase the Snap convertible bond pricing at a high 8.55% cheap bears only the credit risk of Snap, which does not appear to be excessively high given the large capitalization and strong balance sheet of Snap.

5. Financing Convertible Bond Arbitrage

Arbitrage is self-financing in a theoretical framework of perfect capital markets. An arbitrageur simultaneously buys one security while selling an equivalent security at a higher price. When the price disparity between the securities converges, the arbitrageur unwinds the trade by repurchasing the shorted security and selling the one purchased. This strategy requires no up-front capital as the short sale proceeds can finance the security purchased. Under perfect capital markets, a single investor can rapidly scale their arbitrage investments due to the self-financing nature of the trades and immediately force price convergence of the equivalent securities.

In the real world, arbitrageurs must allocate capital to their investments, usually employing a combination of equity and debt financing. Below, we explore the balance sheet and funding costs associated with a convertible bond arbitrage strategy, starting with a single position. Imagine an arbitrageur discovering a convertible bond trading at 2.75% below its intrinsic value, suggesting a potential arbitrage opportunity. The arbitrageur decides to take a long position of $10 million in this convertible bond while shorting $7 million in the underlying stock to hedge the position. To simplify, we assume the arbitrageur finances this trade entirely with $10 million in equity from their arbitrage vehicle.[21] The balance sheet below in Table 6 reflects this initial position in the convertible bond.

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[21] While the real-world arbitrageur will hold a diversified portfolio of convertible arbitrage positions, we start with

Table 6: Balance Sheet for Convertible Arbitrage Position

Assets (millions)	
Long Position (Convertible)	10.0
Cash (Short Proceeds)	7.0
Total Assets	**17.0**

Liabilities (millions)	
Short Position (Stock)	7.0
Equity	10.0
Total Liability & Equity	**17.0**

An arbitrageur manages their long and short positions within a prime brokerage account. Prime brokerage services, typically provided by large investment banks, enable hedge funds to execute and manage complex trading strategies. These services include trade execution, settlement, clearing, securities custody, and financing of positions. Arbitrageurs can execute trades through various broker-dealers or directly with the broker-dealer affiliated with their prime broker. Even for trades conducted with external broker-dealers, the prime broker still oversees settlement and clearing through a "give-up" agreement with the broker that manages the trade. Additionally, many arbitrageurs use multiple prime brokers to diversify counterparty risk and enhance their operational flexibility.[22]

The arbitrageur borrows shares from its prime broker to establish a short position, thereby incurring a $7 million liability on its balance sheet. This liability means the arbitrageur must return the borrowed shares to the prime broker at a later date. The $7 million generated from the short position is recorded as cash on the asset side of the balance sheet; however, it is not available to the arbitrageur. Instead, the cash remains in a segregated account for the benefit of the prime broker. This cash is collateral for the short position, protecting the prime broker against counterparty risk.

We assume that the 2.75% discount on the convertible bond decreases to zero within one year; thus, the arbitrageur anticipates a gross profit of $275,000. However, it's important to note that this convergence could occur sooner or later than expected. Likewise, while we assume the arbitrageur will benefit from the anticipated reduction in the 2.75% discount, the actual profit may differ significantly

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one position for simplicity to illustrate the position's financing. We assume the arbitrageur relies on a combination of internal and external funds (for example, provided by limited partner investors in a hedge fund framework) for equity financing.

[22] For example, financing terms and short availability vary considerably across prime brokers for various securities. Thus, the arbitrageur will selectively use the prime broker offering the best terms for a particular position, spreading its equity capital across multiple prime brokers.

from this expectation. In some cases, the arbitrageur could incur a loss, especially if the issuer experiences financial difficulties.

Table 7: Pro Forma Profit for Convertible Arbitrage Trade

Profit Due to Cheapness Convergence	$275,000
Short Rebate	$276,500
Expected Total Profit	**$551,500**

The prime broker invests the proceeds from short selling in liquid, short-term securities or loans, such as overnight loans to investment banks and financial institutions. In return, the prime broker rebates a portion of the cash to the arbitrageur or hedge fund. Generally, the prime broker uses the Overnight Bank Funding Rate (OBFR) as the benchmark for determining the rebate. The OBFR is a volume-weighted median rate that shows the unsecured overnight borrowing cost between banks, based on federal funds and Eurodollar transactions. For instance, if the OBFR at the time of the transaction is 4.30%, the prime broker may rebate 3.95% to the arbitrageur, keeping 0.35% as an intermediation fee for facilitating the short position.[23]

The expected arbitrage profit is $551,500, as shown in Table 7. This expected profit represents a return of 5.52% relative to the position's value. Given that the OBFR is 4.3%, which is roughly equivalent to the short-term risk-free rate, we can consider the expected excess return of this investment to be 1.22%. Next, we will explore the impact of leverage on the expected return. Leverage is crucial in arbitrage funds, especially in convertible arbitrage funds and within convertible arbitrage strategies in multi-strategy hedge funds. Without leverage, the expected risk and return of a hedged convertible arbitrage strategy remain low, particularly when compared to the fixed costs associated with operating a convertible arbitrage vehicle.[24]

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[23] In the above situation, we assume the underlying stock is in ample supply and easy to borrow. The typical intermediation fee for stocks in plentiful supply will range from 0.20% to 0.50% annually. However, for a hard-to-borrow stock, the rebate can be zero or even negative, meaning the short seller pays a fee on the proceeds instead of receiving a rebate fee.

[24] For this discussion, we define leverage using the ratio of long value to the fund's NAV. Hence, we assume the fund is levered if the ratio exceeds one.

The financing agreement established between an arbitrage firm and a prime broker includes two primary elements: the required collateral and the financing rate. The collateral necessary, referred to as the "haircut," is determined by the underlying risk of the position. A high-moneyness convertible bond hedged with a high delta on the underlying equity is significantly less risky than a low-moneyness convertible bond that relies primarily on indirect hedges, such as treasury futures. As a result, the haircut on the high-moneyness convertible bond is much lower than that of the low-moneyness convertible bond. While the arbitrageur may need to pay for a distressed convertible bond fully, the haircut for a high-moneyness convertible bond might be as low as 10%.[25]

A prime broker charges an arbitrageur a "margin" fee based on the leverage used, typically ranging from an additional 25 to 35 basis points above the Overnight Bank Funding Rate (OBFR). The prime broker has a first-lien claim over all securities and cash held by the arbitrage fund, a process referred to as hypothecation. Since the prime broker serves as the custodian for the arbitrageur's or hedge fund's securities, there is minimal risk that the arbitrageur or hedge fund can misappropriate the collateralized assets outside the prime broker's control. This arrangement significantly mitigates risk for the prime brokerage, allowing it to charge relatively low margin fees to arbitrageurs.

A key feature of the prime brokerage agreement is that the arbitrageur or hedge fund allows the prime broker to rehypothecate their long securities as collateral for a loan from another financial institution through the interbank lending market. In general, investment banks typically do not use a large portion of their balance sheets to finance their hedge fund clients; instead, they often rely on overnight financing from other large banks and financial institutions with excess cash.

Assume the convertible bond described earlier has a haircut requirement of 20% from the prime broker. Imagine that an arbitrage fund successfully constructs a portfolio of several convertible bonds that, for illustrative purposes, resemble this specific convertible bond. In this portfolio, the average discount is 2.75%, the average haircut remains 20%, and the average duration to discount convergence is one year, among other similar characteristics. Table 8 presents the balance sheet and pro forma return metrics for this hypothetical convertible arbitrage fund, which operates with 4x leverage. By

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[25] Before the 2008 GFC, haircuts on high-moneyness convertible bonds were as low as 5%.

leveraging four times rather than the allowable five times, the fund maintains a buffer against potential increases in the haircut or portfolio losses, helping protect the fund's equity.

Table 8: Balance Sheet and Pro Forma Returns for Convertible Arbitrage Fund

Balance Sheet

Assets (millions)		**Liabilities (millions)**	
Convertible Bonds	40.0	Margin Loan	30.0
Cash: Short Proceeds	28.0	Short Stocks	28.0
Total Assets	**68.0**	Equity	10.0
		Total Liabilities	**68.0**

Pro Forma Returns

Expected Gross Profits	1.100
Short Rebate	1.106
Margin Expense	1.395
Total Profits	0.811
Expected Return	8.11%

The balance sheet for the levered convertible arbitrage fund reflects the new debt financing from the prime broker of $30 million. The expected gross profit for the arbitrageur is $1.1 million based on the assumed convergence of the 2.75% cheapness to fair value. Likewise, the short rebate of $1.106 million is simply four times the short rebate in the prior example, assuming the same rebate fees, etc. The cost of financing the $30 million in convertible bonds is $1.395 million, reflecting the OBFR + 0.35%. The net impact of the short rebate and the margin cost is a reduction in the expected profits from $1.1 million to $811,000 or an expected annual return of 8.11%.

As indicated above, the unlevered convertible arbitrage position yields an expected return of 5.52% compared with the 8.11% expected return with four times leverage. You can think of each turn in leverage as increasing the gross profit by $275,000; that is, the expected profit associated with the 2.75% cheapness converging to zero for the unlevered position of $10 million in convertible bonds. The net profit, however, of each turn in leverage is only $86,500, far less than the gross profit of $275,000. The difference is due to the net financing costs. The margin expense of the additional round of leverage is $465,000 (reflecting the OBFR 4.3% + 0.35%). The incremental short rebate is $276,500 (reflecting the OBFR 4.3% - 0.35%).[26] Thus, the net financing cost for a turn in leverage is $188,500. The resulting net expected profit of $86,500 is the difference between the gross anticipated profit of $275,000 and the

[26] Note that the margin expense is on the additional $10 million long position in convertible bonds, and the short rebate is on the extra $7 million short position in the underlying stocks associated with the convertible bond issuers.

net financing cost. Each additional turn of leverage raises the expected return by 86.5 basis points, increasing it from 5.52% to 8.11% with fourfold leverage.

The projected return of 8.11% is significantly higher than the benchmark OBFR return of 4.3%. This projected return is based on our assumption that the current 2.75% undervaluation of the entire portfolio will be eliminated in one year. For the portfolio to generate positive returns, a minimum reduction in cheapness of 0.73% must occur during that year. It's important to note that the portfolio's cheapness might not converge as anticipated; it could widen further, leading to substantial losses for investors in the arbitrage strategy. Consequently, the arbitrageur must maintain adequate borrowing capacity to cushion against potential losses or investor redemptions. These two scenarios are interconnected, as significant losses often lead to investor withdrawals. Indeed, an essential responsibility of a convertible arbitrageur is to ensure the fund maintains a suitable cash cushion to buffer against adverse shocks, that can significantly impair its viability.

6. Concluding Comments

This lecture note has explored convertible bond arbitrage through various examples, starting with the issuance of the Kosmos Energy convertible bond. At its core, the strategy involves purchasing a convertible bond that trades below its fundamental value and hedging the primary sources of systematic risk, most importantly equity exposure, through dynamic short positions in the issuer's stock and, when necessary, through interest-rate and credit hedges.

Importantly, convertible arbitrage isn't just about spotting mispriced securities. It's also important to manage the risks which appear during the convergence process. Just because a security is reliably cheap doesn't mean that it will correct itself right away; in fact, during times of market stress, those price discrepancies can actually widen significantly. As a result, arbitrageurs must manage hedge ratios, liquidity, and financing conditions while maintaining sufficient capital to withstand temporary adverse movements. These considerations explain why convertible arbitrage opportunities can persist even in highly competitive financial markets.

Convertible arbitrageurs play two important roles in the market for convertible securities. First, they provide liquidity to issuers and investors by buying convertibles during periods of selling pressure and selling convertibles when demand temporarily drives prices above their fundamental value. Second, by trading against persistent mispricings, they help align market prices with underlying economic values. Overall, arbitrage contributes to the functioning of the convertible bond market by facilitating capital formation and simultaneously improving price efficiency in a segment of the securities market that is often relatively illiquid.

Appendix: The Evolution of Convertible Pricing Models

This appendix summarizes how successive generations of convertible-bond models have evolved to incorporate optionality, credit risk, and contractual features. The goal is to provide students with a self-contained narrative that they can read without prior exposure to option-pricing math, and to connect the modeling ideas to the hedging choices discussed in this lecture note.

A convertible bond can trade like a bond, a stock, or a combination of the two, depending on the stock's price relative to the conversion price. Additionally, the bond's contractual features—such as issuer calls, holder puts, and make-whole tables—can influence the cash flows. A useful pricing model should:

- Provide a reasonable intrinsic value today—one that reconciles the bond's contractual terms with the market's expectations for equity, credit, and rates.
- Attribute that value to clear drivers—equity (stock level and volatility), interest rates, credit (default risk and recovery), and the legal terms of the bond.
- Deliver practical risk measures, especially delta (share equivalents for hedging) and other Greeks, so a desk can effectively set hedges and manage re-hedging.
- Enable an investor to translate a single market price into either an implied volatility (holding a credit view fixed) or an implied credit spread (holding a volatility view fixed).

The roadmap is historical. It begins with parity versus investment value (Era A), moves to the options revolution and the 'bond + call' framing (Era B), and then shows why recombining lattices became the workhorse for early-exercise features and contractual terms (Era C). From there, subsequent models introduced separate discount curves for debt-like and equity-like cash flows (Era D) and later incorporated explicit credit modeling via hazard-rate or structural mechanisms (Era E).

Era A — Investment Value vs. Parity. Before the development of modern option pricing theory, trading desks triangulated a price between two anchors: investment value (the bond floor, which represents the value of comparable straight debt) and parity (conversion value, calculated as the conversion ratio multiplied by the stock price). This approach anchored intuition (busted vs. equity-like) but lacked a systematic way to price the convertible bond's inherent optionality accurately.

In practice, the traded level sat between these, with a rising "equity weight" as the stock approached the conversion price; thus, optionality was most valuable in the middle range (neither busted nor deep in the money). Figure 1 in the lecture note illustrates this point: a floor-like far OTM, most convex in the hybrid middle, and equity-like when deep ITM. Practitioners explicitly paid for this equity kicker: the premium over parity represented the market's embedded option value, which fluctuated with the moneyness. Prices did reflect the optionality; what Era A lacked was a standard, formal way to measure it.

Era B — Option Model Revolution. The modern era of convertible pricing began with the option-pricing revolution established by Black and Scholes (1973) and Merton (1973). Their work encouraged traders to view a convertible as a *bond + call*—a fixed-income claim plus an embedded option on the issuer's equity. Cox, Ross, and Rubinstein (1979) supplied the numerical bridge from theory to practice with the binomial lattice, which could approximate continuous-time diffusion processes while handling early-exercise features. Although CRR derived their lattice approach for plain options, it became the computational backbone for later convertible-bond models that required path-dependent logic.

Operationally, this framework transformed market practice by introducing disciplined risk measures. Trading desks began quoting and hedging in Greeks, including delta (share equivalents), gamma (convexity), and vega (volatility exposure). The bond + call view enabled translating any market price into an implied volatility, facilitating cheap/rich comparisons and more disciplined hedging than the earlier parity-versus-floor intuition.

Era C — Early Exercise and Optimal Conversion: The next step was to integrate early-exercise behavior and contractual terms directly into valuation frameworks. Brennan and Schwartz (1977, 1980) and Ingersoll (1977) developed structural models in which issuers and holders optimize call and conversion policies. These frameworks solved partial-differential equations numerically, establishing the first rigorous treatment of early-exercise boundaries in convertible bonds.

In practice, this era standardized the recombining binomial and trinomial lattices as the workhorse engines for convertible pricing. Each node represents a possible stock-price state over discrete time steps, with risk-neutral probabilities calibrated to match the risk-free rate, volatility, and dividend or borrow carry. By working backward from maturity, the model tests at every node whether it is optimal to convert, call, put, or continue, thereby generating both the price and the early-exercise boundary.

This discrete-time approach improved on the continuous Black–Scholes framework, which assumes European-style exercise. Lattices naturally incorporate call schedules, holder puts, soft-call tests, and make-whole provisions; they also produce hedge ratios that respect the exercise frontier. The resulting outputs—price, delta, gamma, and implied volatility—enabled traders to mark, hedge, and compare convertibles systematically.

However, the main limitation lay in credit treatment: most implementations at the time still used a single "risky" discount rate or a constant spread across the tree, which blurred the equity and credit effects. By discounting everything at a single risky discount rate, the pricing model effectively penalized the equity option as if the issuer could default on the stock.[27] That inconsistency motivated the next breakthrough—the two-curve framework, which separates debt-like and equity-like discounting (Era D) and, later, the explicit modeling of default events (Era E).

Era D — The Two-Curve Breakthrough: After the lattice era, the next cleanup was conceptual rather than computational: stop discounting every cash flow with one 'risky' rate. The promised payments for a convertible are split into two categories. One consists of debt-like cash flows, such as coupon payments and principal payments at maturity, that the investor expects to receive unless the issuer defaults. The other consists of equity-like outcomes such as conversion into stock.

Tsiveriotis and Fernandes (1998) formalized this insight by splitting the convertible bond into two coupled components: a bond component discounted at the risky yield curve (risk-free rate + credit spread) and an equity component discounted at the risk-free rate curve. Their convertible pricing model solves a pair of linked partial differential equations, in which the debt component decays with credit risk, while the equity component evolves under risk-neutral diffusion. The two-curve separation prevented the

[27] In effect, using the single risky discount rate double-counts credit risk. First, in this approach, credit risk enters a convertible's price through the discount rate (the spread), thereby reducing its present value. Second, credit risk affects the convertible price through the stock price; that is, weak credit shows up as a lower stock price. Consequently, when you apply the risky discount rate to both the bond and the equity components, you count the same credit deterioration twice.

old double-counting of credit. Now, the equity component only indirectly reflects the credit spread through its impact on the stock price.

Practically, the two-curve framework transformed risk attribution by clarifying that the credit spread drives the bond floor, while implied volatility drives the conversion premium. It also enabled 'twin-implied' analysis: holding one view fixed (vol or credit) to solve for the other implied input. Yet, the two-curve model still implicitly embeds default in discounting. The debt component was penalized by the credit spread, but it never actually defaulted. The equity component could not jump to zero, and the correlation between equity moves and credit risk was nonexistent. In volatile or distressed names, that limitation mattered. An actual default should extinguish the equity leg and apply recovery to the debt leg within the same lattice. This realization motivated the next advance, explicit credit modeling, which overlaid hazard-rate or structural mechanisms onto the two-curve foundation.

Era E — Explicit Credit Modeling: The final major theoretical leap in convertible valuation came from bringing default events explicitly into the model rather than hiding them in discount factors. Duffie and Singleton (1999) introduced reduced-form or hazard-rate credit models, in which default follows a Poisson process with an intensity calibrated to observed credit spreads. Years earlier, Merton (1974) offered an alternative structural view: default occurs when firm value crosses a liability barrier.

Building on these approaches, Ayache, Forsyth, and Vetzal (2003) developed finite-difference models with explicit embedded credit layers. In these implementations, each time step of the lattice or PDE incorporates both survival and default branches. When a default occurs, the equity-like leg is wiped out, and the debt-like leg pays recovery. When survival occurs, valuation proceeds normally. This explicit treatment allows the model to capture equity-credit correlation; for example, falling stock prices raise default intensity and produce coherent sensitivities across shocks. Credit spreads and implied volatility now interact endogenously; widening spreads reduce the bond floor and, through correlation, dampen the equity option's value. Modern trading systems now integrate these elements — volatility, credit, and term-structure dynamics — into unified convertible valuation engines, forming the foundation for today's market-standard model.